UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	P00,1472
First Named Inventor or Application Identifier	
Thomas Zelenka	
Express Mail Label No: #EK045414489US	

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, DC 20231

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. X Specification [Total Pages 17]
2. X Drawing(s) (35USC 113) [Total Pages 4]
3. X Declaration and Power of Attorney [Total Pages 2]

a. __ Executed declaration (Original copy)

b. __ Copy from prior application (37CFR 1.63(d))
(for continuation/divisional with Box 14 completed)

i. __ ***[Note Box 4 Below]***
DELETION OF INVENTOR(S)
Signed statement attached deleting Inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

4. __ Incorporation By Reference (usable if Box 3b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 3b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

ACCOMPANYING APPLICATION PARTS

5. __ Assignment Papers (cover sheet & documentation)

6. X Letter under 37 CFR 1.41(c).

7. __ English Translation Document *(if applicable)*

8. X Information Disclosure Statement (IDS)/PTO-1449 X Copies of IDS Citations

9. __ Preliminary Amendment

10. X Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)

11. __ Small Entity Statement(s) __ Statement filed in prior application, Status still proper and desired

12. X Certified Copy of Priority Document(s) German Application No. 199 42 551.5 filed September 7, 1999

13. __ Other:

14. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information:*

__ Continuation __ Divisional __ Continuation-in-part (CIP) __ of prior application No: /

CLAIMS AS FILED

(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) BASIC FEE $690.00
TOTAL CLAIMS 20	13			
INDEPENDENT CLAIMS 3	4	1	$78.00	$78.00
	ANY MULTIPLE DEPENDENT CLAIMS? ()YES (X) NO			
			TOTAL FILING FEE ->	$768.00

X The Commissioner is hereby authorized to charge any additional fees which may be required in connection with this application, or credit any overpayment to ACCOUNT NO. 501-519. A duplicate copy of this sheet is enclosed.

X A check in the amount of $ 768.00 to cover the filing fee is enclosed.

15. CORRESPONDENCE ADDRESS

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DATE: September 6, 2000

JS/BV:BC
U-11

SPECIFICATION

TITLE

"METHOD AND CIRCUIT ARRANGEMENT FOR DRIVING LASER DIODES"

BACKGROUND OF THE INVENTION

The invention is in the field of electronic reproduction technology and is directed to a method and a circuit arrangement for driving laser diodes arranged in close proximity to one another, for example on a common carrier, in laser recording devices, whereby the term laser recording devices is intended to include laser exposers, laser printers and digital printing machines, among others.

In a laser recording device, a laser beam modulated by a video signal is conducted point-by-point and line-by-line across a recording material that is clamped on a materials' holder movable relative to the laser beam.

Multi-beam recording elements are employed for increasing the recording speed. A multi-beam recording element comprises a plurality of individually controllable laser diodes that generate a plurality of parallel laser beams for the recording.

Strip-shaped laser diode arrangements, what are referred to as laser diode bars, are frequently employed, these being respectively composed of a plurality of laser diodes arranged in close proximity on a shared substrate carrier that have individually electrically drivable emitters.

Since the light power output by the laser diodes is highly temperature-dependant, the heating of a laser diode -- due to the extremely slight spacings of the laser diodes on the substrate carrier -- can disturbingly influence the temperatures of neighboring laser diodes and, thus, their light power, an effect that is referred to as thermal crosstalk. Due to the slight spacings of the laser beams from one another, further, neighboring laser beams can mutually influence one another, an effect that is called optical crosstalk. The recording quality of a laser recording device is considerably deteriorated due to such crosstalk.

For crosstalk compensation in laser diode arrangements, it is know to either keep the working temperature of the individual laser diodes constant by heating and cooling or to keep the light powers output by the laser diodes constant by regulating their driver currents.

EP 0 738 071 B discloses a method for the operation of a laser diode arrangement wherein correction signals are formed by weighting selected video signals with weighting coefficients stored in a table memory (look-up table; LUT). For the purpose of a crosstalk compensation, the video signals are corrected by the correction signals and the corrected video signals are then converted into the driver currents for the laser diodes.

The known method does not take into consideration that the thermal crosstalk is dynamic, i.e. that the temperature influencing on neighboring diodes occurs with a time curve. For this reason, the known method is not suited for being utilized for fast modulation of the laser beams in a laser recording device.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to improve a method and a circuit arrangement for driving laser diodes arranged in close proximity in a laser recording device such that thermal and optical crosstalk of the laser diodes are dynamically compensated.

According to the method and apparatus of the invention for driving laser diodes arranged in close proximity to one another in a laser recording device, each laser diode is charged by a driver current that determines a light power output by the laser diode. With the driver currents, controlling video signals modulated with information to be recorded are controlled. A first correction unit is connected between a first laser diode forming a crosstalk source and a second laser diode forming a crosstalk sink. The correction unit is charged with the video signal or the driver current of the first laser diode. The correction unit is connected with the video signal or the driver current of the first laser diode. An output signal of the correction unit is employed as a correction signal for the video signal or for the driver current of the second laser diode. A transfer function of the correction unit is determined such that an optimum compensation of crosstalk is achieved between the laser diodes.

The invention is explained in greater detail below with reference to Figures 1 through 4.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of a multi-beam recording element;

Figure 2 is an exemplary embodiment of a drive circuit;

Figure 3 shows time curves, for example explaining a crosstalk compensation; and

Figure 4 is another exemplary embodiment of a drive circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a schematic exemplary embodiment of a multi-beam recording element in a laser recording device. The multi-beam recording element essentially comprises a drive circuit 1, a laser beam generator 2, an optical lens 3 and an objective 4. The laser beam generator 2 is designed as a strip-shaped laser diode arrangement, called a laser diode bar in brief. The strip-shaped laser diode arrangement is composed of a plurality -- five in the illustration -- of laser diodes 5 arranged in a row and spaced from one another. The laser diodes 5, whose emitters can be individually driven with the drive circuit 1, are located on a common substrate carrier 6. The substrate carrier6 is arranged such that the laser beams 7 generated by the laser diodes 5 emerge from the laser beam generator 2 parallel to an optical axis 8 of the multi-beam recording element.

The optical lens 3 in front of the laser beam generator 2 is designed as an aspherical lens, for example a cylindrical meniscus lens, whose longitudinal extent is directed perpendicular to the optical axis 8. An asymmetrical beam expansion transverse to the optical axis 8 is compensated by the cylindrical meniscus lens 3.

The objective 4 is arranged on the optical axis 8 at that side of the optical lens 3 facing away from the laser beam generator 2. The objective 4 forms the

individual light exit faces of the laser diodes 5 in the required scale as a row of illumination points 9 on the recording material 10 of the laser recording device (not shown in greater detail). The illumination points 9 generate illumination lines lying side-by-side on the recording material 10 due to a relative movement between recording material and multi-beam recording element.

Figure 2 shows an exemplary embodiment of a drive circuit 1 for the laser beam generator 2 that is designed as a strip-shaped laser diode arrangement (laser diode bar) according to Figure 1. For the sake of clarity, only three specific laser diodes (5_A, 5_B, 5_C) of the laser diode arrangement are shown for three channels A, B and C in Figure 2. The illustrated arrangement is repeated correspondingly given more channels.

The channels A, B and C comprise controllable current sources 12_A, 12_B, 12_C for generating the driver currents I_{TA}, I_{TB}, I_{TC} for the laser diodes 5_A, 5_B, 5_C with a respective control input $12'_A$, $12'_B$, $12'_C$ and a correction input $12"_A$, $12"_B$, $12"_C$.

Analog or digital video signals V_A, V_B and V_C that are modulated with the information to be recorded are supplied to the control inputs $12'_A$, $12'_B$, $12'_C$ of the current sources 12_A, 12_B, 12_C and control the light powers P_A, P_B and P_C of the laser diodes 5_A, 5_B, 5_C via the driver currents I_{TA}, I_{TB}, I_{TC}.

As already explained, the working temperature of a laser diode (crosstalk source) in one of the channels influences the working temperatures of the laser diodes (crosstalk sink) in the neighboring channels time-delayed by thermal crosstalk as a result of the laser diodes lying in such close proximity to one

another and, due to the dependency of the light power on the working temperature, also influences the light powers output by the laser diodes. Additionally, the light power can be influenced by optical crosstalk of the laser beams.

In Figure 2, for example, the working temperature of the laser diode 5_A in the channel A influences the working temperature of the laser diode 5_B in the neighboring channel B , and the working temperature of the laser diode 5_B in the channel B influences the corresponding working temperatures of the laser diodes 5_A, 5_C in the neighboring channels A and C.

The disruptive thermal and optical crosstalk of the channels onto neighboring channels is compensated according to the invention by electronic feedback of correction signals K onto at least the immediately neighboring channels. The correction signals K for neighboring channels are acquired from the video signal V or from the driver current I_T of the channel lying between the neighboring channels. The acquisition of the correction signals K occurs with linear or non-linear quadripoles whose transfer functions correspond to the time curves of the temperature T = f(t) or the light power P = f(t) in at least the immediately neighboring channels caused by the crosstalk.

The method of the invention is explained by way of example for the crosstalk compensation of the channel A onto the neighboring channel B.

Before the crosstalk compensation, the time curve of the temperature T_B = f(t) or the time curve of the light power P_B = f(t) in the neighboring channel B is determined, this deriving due to the crosstalk effect from channel A onto

channel B. The determination of the time curve of the light power has the advantage that both the thermal as well as the optical crosstalk are covered.

For this purpose, the channel A is charged with a video signal pulse V_A and the channel B is charged with a constant video signal V_B, so that the channel A works in switched mode and the channel B works in continuous mode. Due to activation of the laser diode 5_A in the channel A, the working temperature thereof is increased. The laser diode 5_B in the neighboring channel B heats in time-delayed fashion due to the thermal crosstalk and its light power P_B drops with the time as a consequence of the heating. The time curve of the temperature $T_B = f(t)$ or of the light power $P_B = f(t)$ in the channel B is then measured.

Subsequently, the time curve of the temperature $T_B = f(t)$ of the laser diode 5_B or of the light power $P_B = f(t)$ is simulated by an electrical quadripole and is input into a first correction unit 14. The quadripole can be designed as a linear low-pass that -- in the simplest case -- is constructed of an RC element, preferably of a combination of RC elements. The determination of "R" and "C" of the RC elements occurs by polynomial approximation according to known calculating methods. The required time curve of the driver current $I_B = f(t)$ is determined and employed for the scaling of the transfer function of the quadripole, being determined from the known relationship between the light power P and the driver current I_B, which is assumed to be approximately linear at least in the operating range, and from the measured function $P_B = f(t)$.

In the crosstalk compensation, a correction signal K_{AB} is then generated in the first correction unit 14 from the video signal V_A or, respectively, from the driver current I_{TA}, the correction signal being forwarded to the correction input $12"_B$ of the current source 12_B for the correction of the driver current I_{TB}. The correction signal K_{AB} corresponds to the time change of the temperature or of the light power in the channel B dependent on the video signal V_A or on the driver current I_{TA} of the channel A. The correction signal K_{AB} corrects the driver current of the laser diode 5_B in the channel B in such a way that the drop of the light power P_B in the channel B caused by the crosstalk is compensated, whereby the relationship between driver current and light power is assumed to be approximately linear.

In the drive circuit 1 shown in Figure 2, moreover, a correction signal K_{BA} acting from channel B onto channel A is acquired in a second correction unit 15, a correction signal K_{BC} acting from channel B onto channel C is acquired in a third correction unit 16, and a correction signal K_{CB} acting from the channel C onto channel B is acquired in a fourth correction unit 17.

Figure 3 shows time curves for explaining the compensation of the crosstalk from channel A onto channel B.

Time diagram A) shows the rectangular curve of the light power P_A in the channel A during the on-time interval of the laser diode 5_A.

Time diagram B) shows the curve (20) of the working temperature T_B as well as the curve 21 of the light power P_B of the laser diode 5_B in the channel B

resulting due to the crosstalk from channel A. The drop in light power caused by the crosstalk can be seen.

Time diagram C) shows the correction signal K_{AB} generated for the channel B for the compensation of the crosstalk from channel A onto channel B.

Time diagram D) shows the curve of the driver current I^*_{TB} for the laser diode 5_B in the channel b corrected with the correction signal K_{AB}.

The time diagram E) shows the curve of the light power P_B of the laser diode 5_B in the channel B after the crosstalk compensation, the disruptive drop in light power having now been eliminated.

In the exemplary embodiment of a drive circuit ( ) shown in Figure 2, the crosstalk from one channel onto the immediately neighboring channels is compensated.

It lies within the scope of the invention to expand the crosstalk compensation onto more distant channels, for example to compensate the crosstalk of channel A not only in the immediately neighboring channel B but also in the more distant channel C.

Figure 4 shows portions of a drive circuit 1 for an expanded crosstalk compensation. For additional compensation of the crosstalk from channel A onto channel C, the illustrated drive circuit 1 comprises a further correction unit 18 in which the time curve of the temperature $T_C = f(t)$ of the laser diode 5_C or of the light power $P_C = f(t)$ in the channel C as a result of a temperature change of the laser diode 5_A is simulated. Dependent on the driver current I_{TA}, the correction unit 18 generates an additional correction signal K_{AC} that is supplied

to the current source 12_c for the correction of the driver current I_{TC} for the laser diode 5_c.

Although various minor modifications might be suggested by those skilled in the art, it should be understood that my wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come with the scope of my contribution to the art.

I CLAIM AS MY INVENTION:

1. A method for driving laser diodes arranged in close proximity to one another in a laser recording device, comprising the steps of:

charging each laser diode by a driver current that determines a light power output by the laser diode;

with the driver currents, controlling video signals modulated with information to be recorded;

connecting a correction unit between a first laser diode forming a crosstalk source and a second laser diode forming a crosstalk sink;

controlling the correction unit with the video signal or the driver current of the first laser diode;

employing an output signal of the correction unit as a correction signal for the video signal or for the driver current of the second laser diode ; and

determining a transfer function of the correction unit such that an optimum compensation of crosstalk is achieved between the laser diodes.

2. The method according to claim 1, for determining the transfer function of the correction unit wherein

a the time curve of a temperature of the second laser diode forming the crosstalk sink that arises as a consequence of the crosstalk is determined; and

the identified time curve of the temperature is approximately electrically simulated by the correction unit as the transfer function.

3. The method according to claim 1, wherein for determining the transfer function of the correction unit

a time curve of a light power of the second laser diode forming the crosstalk sink that arises as a consequence of the crosstalk is determined; and

the identified time curve of the light power is approximately electrically simulated by the correction unit as the transfer function.

4. The method according to claim 1 wherein for determining a time curve of a temperature or of a light power

turning on and off the first laser diode forming the crosstalk source by a driver current pulse;

operating the second laser diode forming the crosstalk sink in continuous mode by a constant driver current;

measuring the time curve of the temperature or of the light power of the second laser diode dependent on the time as a first function; and

the time curve of the driver current of the second laser diode is determined from the first function and a second function that reproduces the curve of the light power of the second laser diode dependent on the driver current.

5. The method according to claim 1 wherein the connection unit is electrically realized by a linear low-pass filter having at least one RC element.

6. The method according to claim 1 wherein the laser diodes forming the crosstalk sinks are those laser diodes that at least immediately neighbor the laser diode forming the crosstalk source.

7. The method according to claim 1 wherein

a correction unit is allocated to every crosstalk sink to be taken into consideration for a crosstalk source;

transfer functions of the correction units are formed from characteristic time curves of a temperature or light power in the respective crosstalk sinks;

the correction units are charged with the driver current of the laser diode forming the crosstalk source; and

output signals of the quadripoles are respectively employed as correction signals for the video signals or the driver currents of the laser diodes forming the crosstalk sinks.

8. The method according to claim 1 wherein the driver currents for the laser diodes are generated in current sources that are controlled by the video signals and the correction signals.

9. A circuit arrangement for driving laser diodes arranged in close proximity to one another in a laser recording device, comprising:

generators controlled by video signals for generating driver currents for the laser diodes that determine light powers output by the laser diodes;

correction units for generating correction signals for compensation of crosstalk between the laser diodes;

the correction units dependent on the video signals or driver currents for the laser diodes, approximately electrically simulating time curves of the temperatures or light powers of the individual laser diodes arising as a consequence of the crosstalk; and

outputs of the correction units are connected to the generators in order to correct the video signals or driver currents with the correction signals.

10. The circuit arrangement according to claim 9 wherein the generators are current sources driven by the video signals.

11. The circuit arrangement according to claim 9 wherein the correction units are designed as linear low-pass filters.

12. A method for driving laser diodes arranged adjacent to one another in a laser recording device, comprising the steps of:

connecting each laser diode with a driver current related to a light power output by the laser diode;

with the driver currents, controlling video signals modulated with information to be recorded;

connecting a correction unit between a first laser diode forming a crosstalk source and a second laser diode forming a crosstalk sink;

controlling the correction unit with at least one of the video signal and the driver current of the first laser diode;

employing an output signal of the correction unit as a correction signal for at least one of the video signal and driver current of the second laser diode ; and

determining a transfer function of the correction unit such that compensation of crosstalk is achieved between the laser diodes.

13. A circuit arrangement for driving laser diodes arranged adjacent to one another in a laser recording device, comprising:

generators controlled by video signals for generating driver currents for the laser diodes that determine light powers output by the laser diodes;

correction units for generating correction signals for compensation of crosstalk between the laser diodes;

the correction units dependent on at least one of the video signals and driver currents, approximately electrically simulating time curves of at least one of the temperatures and light powers of the individual laser diodes arising as a consequence of the crosstalk;

the correction units are connected with at least one of the video signals and the driver currents for the laser diodes; and

outputs of the correction units are connected to the generators in order to correct at least one of the video signals and the driver currents with the correction signals.

ABSTRACT OF THE DISCLOSURE

In a method and a circuit arrangement for driving laser diodes arranged in close proximity to one another in a laser recording device, video signals modulated with the information to be recorded generate driver currents for the laser diodes. The light powers output by the laser diodes drop due to crosstalk between the laser diodes. For compensation of the crosstalk, correction units are connected between first laser diodes that form crosstalk sources and second laser diodes that form crosstalk sinks. In the correction units, the driver currents of the first laser diodes are converted into correction signals according to the transfer functions of the correction units, the correction signals correcting the driver currents of the second laser diodes such that the crosstalk is compensated. For determining the transfer functions of the correction units, the time curves of the light powers in the crosstalk sinks are measured and approximately electrically simulated as transfer functions.

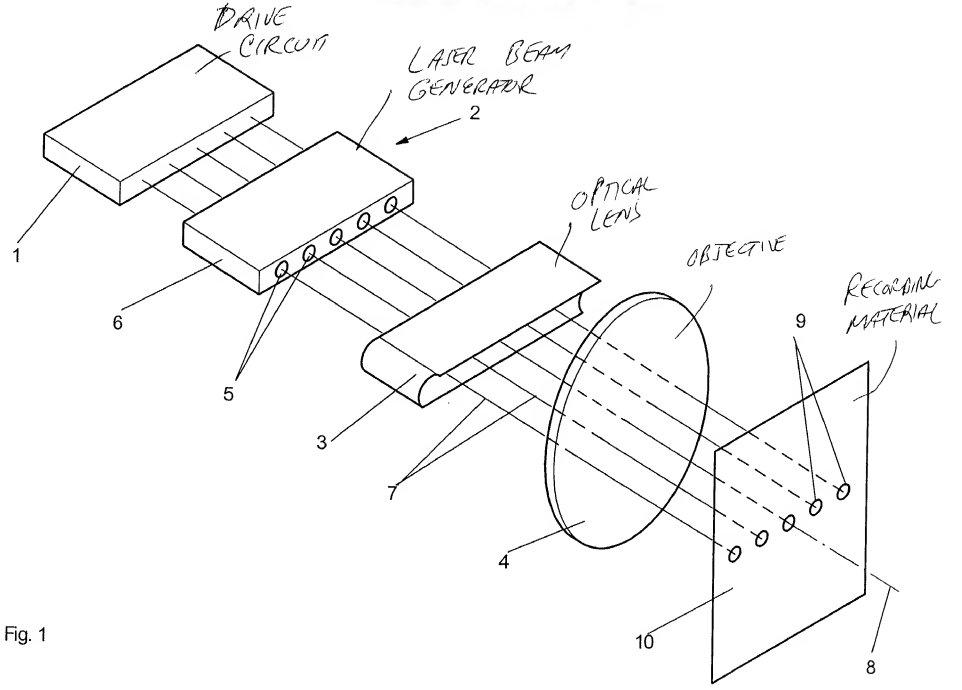
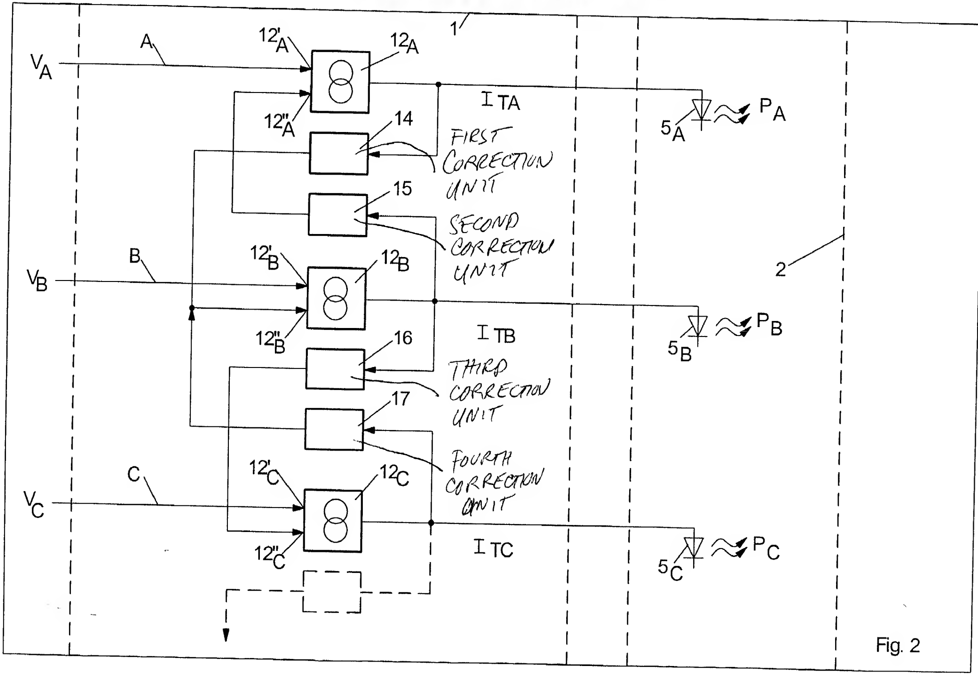


Fig. 1



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FIRST CORRECTION UNIT
SECOND CORRECTION UNIT
THIRD CORRECTION UNIT
FOURTH CORRECTION UNIT

Fig. 2

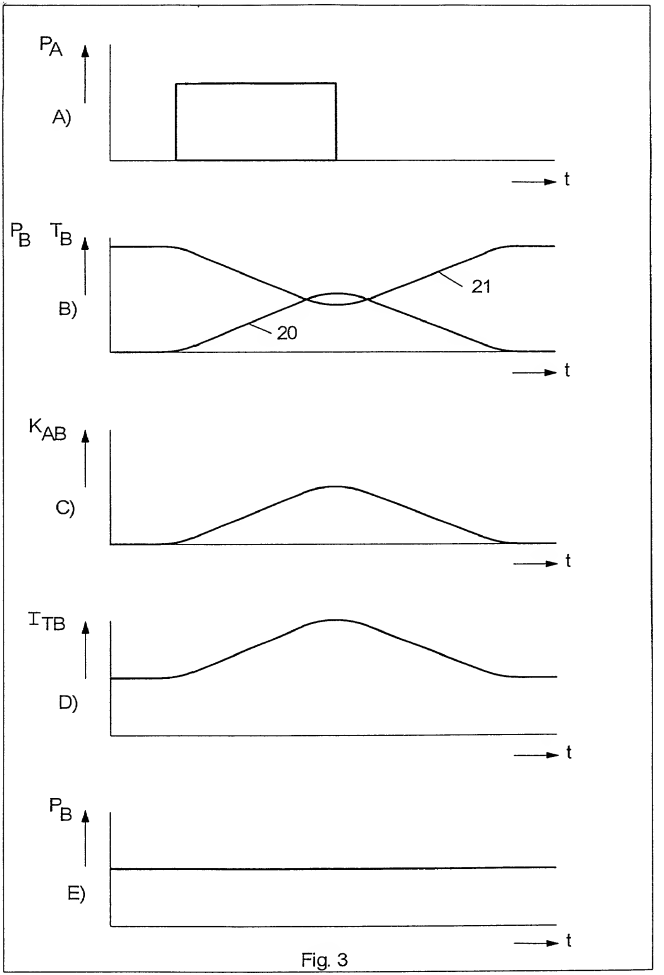
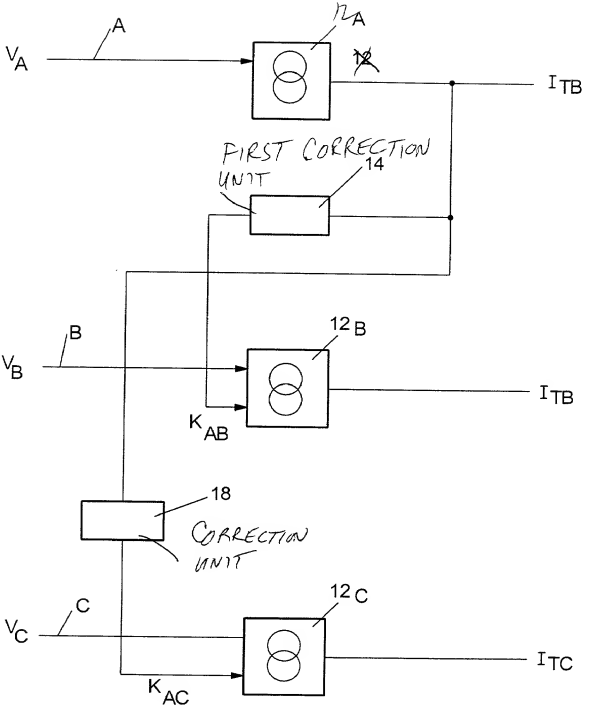


Fig. 3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K_{AC}

Fig. 4

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"METHOD AND CIRCUIT ARRANGEMENT FOR DRIVING LASER DIODES"

Case No. **P00,1472**, the specification of which

	X	is attached hereto.
(check one)	__	was filed on _____, as Application Serial No._____. and was amended on _____. (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent Office all information which is known to me to be material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, 1.56.[1]

I do not know and do not believe this invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and I believe that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as identified below:

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below

Prior Foreign Application(s)

Number	Country	Date
199 42 551.5	**Germany**	**September 7, 1999**

and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the above listed application on which priority is claimed:

Prior Foreign Application(s)

Number	Country	Date

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[1] (b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

If no priority is claimed, I have identified all foreign patent applications filed prior to this application:
Prior Foreign Application(s)
Number Country Date

And I hereby appoint Messrs. John D. Simpson (Registration No. 19,842), Steven H. Noll (28,982), Brett A. Valiquet (27,841), James D. Hobart (24,149), Melvin A. Robinson (31,870), and Mark Bergner (45,877), all members of the firm of Schiff, Hardin & Waite
Telephone: 312/258-5500 Ext. 5786
my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and direct that all correspondence be forwarded to:

Schiff, Hardin & Waite
Patent Department
6600 Sears Tower, Chicago, Illinois 60606

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor **THOMAS ZELENKA**

Inventor's signature_____ Date_____
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Full name of second joint inventor,
(if any)_____

Inventor's signature_____ Date_____
Residence
Citizenship
Post Office Address

Full name of third joint inventor,
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Inventor's signature_____ Date_____
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Office Address_____